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Education

Some Underused Tools for Assessing the Effects of Major Emergencies

by Pete Brewster

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Introduction

This article identifies and describes some little used tools available in major metropolitan areas that can be used to prepare a profile of the effects of a disaster over the response and recovery period. This profile would afford those responsible for emergency management a rapid method to perform the initial assessment, project the potential mass care requirements, provide targets for immediate reconnaissance, and expedite any requests for support from external governments. Two problems with "managing disasters" are the time normally required to assess the extent of

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damage in the community, and the lack of a simple process that would assist in anticipating demands, setting priorities, identifying/requesting resources, etc. This article is limited to describing an inexpensive method that can be used to develop a basic profile useful for any type of major emergency. What follows is the conceptual basis behind this discussion, some of the key components of a disaster effects profile and decision process, and how it could be used by local governments to lead response, recovery, and restoration activities.

Overview

Elected officials and municipal public safety agencies are responsible for ensuring the health and welfare of citizens. Current approaches for community preparedness are focused on hazard identification, capability assessment, and development of all-risk emergency operations plans.(1) Many plans, however, lack a simple decision process that can be used

Table 1: General Effects of Hazards

Primary Hazards and Secondary Hazards	General Effects	Infrastructure and Social Functions
Ground Shaking Fire, HazMat Tsunami/flooding Land/mud/snow slides	Above/below grade damage to man-made structures	Transportation system Buildings Parking garages Flood control
	Disruption of utility services	Natural gas Potable water Wastewater Electric power Communications
	Other effects	Loss of housing Loss of economic activity Debris
Wind Flooding	Above grade damage to man-made structures	Buildings Signage and lighting Antennas Power lines
	Disruption of utility services	Electric power Potable water Wastewater Communications

to initiate management activities during a major event. Thus, "management" (agency officials responsible for day-to-day municipal service delivery) gets behind the power curve and is in a reactive position until the event is over. The development of a decision process based upon the event characteristics and the community's social functions can help management anticipate what is needed next by responders (and expected by citizens). Our nation's metropolitan areas contain 77.5 percent of the

Fires, HazMat	Other effects	Loss of housing Loss of economic activity Debris Water Landslide HazMat
Water Landslide HazMat	Above/below grade damage to man-made structures	Transportation system Buildings Parking
	Disruption of utility services	Electric power Potable water Wastewater Communications
	Other effects	Loss of housing Loss of economic activity Debris
Fire With rain, landslides HazMat	Above/below grade damage to man-made structures	Buildings
	Disruption of utility services	Electric Power
	Other effects	Loss of housing Loss of economic activity Debris
Severe	Above/below grade damage to man-made structures	Transportation system Buildings

population.(2)
Each of these areas face moderate risks from a wide variety of natural, man-made, and technological hazards, and their particular geographic locations predispose some of them to catastrophic events (e.g., hurricanes along the Eastern Seaboard and Gulf Coast; earthquakes in the Central United States, California, Oregon, and Washington; etc.). While these population centers are different in many ways, they all share similar social functions (where people engage in work and leisure activities), and

Heat/Cold
Drought/fires
Thaw/flooding

Disruption of utility services

Electric power
Potable water
Wastewater

Other effects

Loss of housing
Loss of economic activity

Table 2: Essential Services, Critical Facilities, and Infrastructure (8)

Essential Services	Critical Facilities	Infrastructure
Law enforcement Fire and rescue EMS/definitive care Media/information Continuity of government	Public safety comm. centers Hospitals Clinics Congregate care Laboratories Pharmacies Schools Institutions High occupancy structures	Roads Bridges Dams and levees Landfills Utility Services Electric Potable water Wastewater Natural gas Telephone

Table 3: Sample Electric Power Restoration Priorities (12)

face similar demands for service after disasters strike. Further, the residents of our urban areas are more and more vulnerable because of increasing population density, continued migration to high-risk areas, and the growth of certain segments of the population who are particularly vulnerable to the effects of major emergencies (such as the elderly, the poor, and the non-English speaking).(3)

Demands on Service Delivery

E. L.

Water supply pumping stations	Sewage lift stations
Hospitals	Airports
Public safety communications centers	Food processing plants
Nursing homes	Industrial and commercial businesses
Telephone and radio/TV stations	Residential customers (assigned higher in the heating season)
Storm Water pumping stations	

**Table 4:
Sample Population Density
by Social Function by Time and
Day**

WEEKEND	WEEKDAYS
<i>12 a.m. to 6 a.m.</i> Residential Industrial Government (Emergency Services)	<i>12 a.m. to 6 a.m.</i> Residential Industrial Government (Emergency Services)
<i>6 a.m. to 6 p.m.</i> Residential Transportation Religion Commercial Industrial Government	<i>6 a.m. to 4 p.m.</i> See Table 5
<i>6 p.m. to 12 a.m.</i> Residential	<i>4 p.m. to 9 p.m.</i> Transportation Commercial Residential Industrial Government (Emergency Services)

Quarantelli described how two different sets of demands occur simultaneously during disasters: "Agent-Generated Demands" (those caused by the primary and secondary hazards): warning, pre-impact preparation, search and rescue, care of the injured and dead, welfare needs, restoration of essential services, protection against continuing threat, and community order; and "Response-Generated Demands" (those caused within and between responding agencies):

Commercial
Industrial
Government
(Emergency Services)

9 p.m. to 12 a.m.
Residential
Industrial
Government
(Emergency Services)

**Table 5:
An Inventory of Population Density
by Social Function (16)**

Social Function Classification	Occupants Per 1,000 Square Feet	
	3:00 pm	3:00 am
A. Residential		
1. Permanent dwelling	1.2	3.1
2. Temporary lodging	0.6	2.5
3. Group institutional housing	2.0	3.0
B. Commercial		
1. Retail trade	10.0	-
2. Wholesale trade	1.0	-
3. Personal and repair service	4.0	0.1
4. Professional, technical, and business services	4.0	-
5. Health care services	5.0	2.0
6. Entertainment and recreation	6.0	-
7. Parking	0.2	-
C. Industrial		
1. Heavy fabrication and assembly	3.0	0.3

communications continuing assessment of the situation, mobilization and utilization of resources, coordination, and exercise of authority.(4) One important aspect in disaster management involves timing. It is a large determinant of deaths and injuries based on when the disaster event occurs (time of day, day of the week), but also based on the amount of time a metropolitan area has to prepare for the event (whether or not there was a warning period). The amount of time a community has to take protective

2. Light fabrication and assembly	5.0	0.3
3. Food and drug processing	2.5	0.3
4. Chemical processing	2.5	0.3
5. Metal and mineral processing	1.2	0.1
6. High technology	3.0	0.3
7. Construction	4.0	0.1
8. Petroleum	2.5	0.3
D. Agriculture	0.2	-
E. Mining	4.0	-
F. Religion and Nonprofit	65.0	-
G. Government		
1. General services	4.0	-
2. Emergency response services	3.0	0.4
H. Education	20.0	-
I. Transportation Services		
1. Highway (roads and bridges)	NA	NA
2. Highway (truck terminals)	1.0	0.4
3. Railway (train terminals)	10.0	0.2
4. Air (air terminals)	10.0	0.2
5. Sea (sea terminals)	3.0	0.2
J. Utilities (Office Buildings)		
1. Electrical	14.0	0.2
2. Water	4.0	0.2
3. Sanitary sewer	4.0	0.2
4. Natural gas	4.0	0.2
5. Telephone and telegraph	4.0	1.0
K. Communications	4.0	1.0
L. Flood Control	-	-

actions and to organize its emergency services can save lives and protect property(5) (e.g., Sioux City, Iowa, aircrash; evacuation efforts prior to Hurricane Andrew, etc.). Realizing that most events give little or no warning, and that interagency coordination and the ability for all of the various organizations to communicate are classic problems,(6) managers and responders must have agreement on the organization, management, and coordination structures they will use (e.g., all emergency services

Table 6: Sample General Activities by Time Phase (17)

<i>Pre-Impact</i>	<i>Initial Response</i>
Warning Protective Actions	Situation Assessment Fire Suppression/Hazmat Control Search and Rescue Emergency Medical Care Public Information Debris Clearance
<i>Recovery/Reconstruction</i>	<i>Extended Response/Recovery</i>
Service Restoration Business Restoration Permanent Housing Debris Disposal	Mass Care (Food, Clothing & Shelter) Individual and Public Assistance Essential Service Restoration Temporary Housing Debris Removal

Table 7: Sample GIS Mapping Features (18)

agencies use the incident management system, and managers understand their roles and functions in the emergency operating center).

General Effects

Using several natural hazards which have the potential to affect large areas of our nation's cities, Table 1 suggests that we can anticipate certain types of damage, and strains on normal service delivery. Obviously, the information is not complete, but the idea behind it is to point out that we can anticipate the

Paved roads	Addresses, parcel designators
Alleys/unpaved roads	Flood zones
Railroads	Contours
Airports, airfields	Spot elevations
Parking	Lakes and river names
Bridges	Zoning boundaries
Street centerlines	Utility easements
Structures	Tax districts
Fences, walls, recreation areas	GPS section corners
Lakes, rivers, streams, drainage	Census tract boundaries
Dams, major culverts	Natural gas main pipes
Minor culverts	Natural gas transmission lines
Poles	Water pipes
Utility towers	Water hydrants
Manholes	Water valves
Parcel lines, subdivision boundaries	Water hydrant branches
Easements	Storm sewer lines
Subdivision names	Sanitary sewer mains

Table 9: Sample Key Sources of Information

- Utility control centers (outages)
- Electric power
 - Natural gas
 - Water
 - Telephone
- Public safety dispatch centers
Public reports
Patrols/reconnaissance
Amateur radio operators
Media coverage
Aerial/ground reconnaissance

kinds of damages associated with the type of hazard.

Essential Services, Critical Facilities, and Infrastructure

For the purposes of this discussion, essential services are defined as those services that municipalities must try to continue to provide at all times. Critical facilities support essential service delivery, or are high occupancy structures. Infra-structure represents the basic facilities, equipment, and

Table 10: Sample Transition Planning Device (20)

Status of Community Service Delivery	Red	Amber	Green
Public Safety			
Communication Centers	—	—	—
Law Enforcement	—	—	—
Fire and Rescue	—	—	—
Emergency Medical Services	—	—	—
Health Care Facilities and Resources			
Hospitals	—	—	—
Clinics	—	—	—
Congregate Care	—	—	—
Pharmacy	—	—	—
Transportation			
Highways	—	—	—
Railroads	—	—	—
Airports	—	—	—
Utilities			
Electric	—	—	—
Potable Water	—	—	—
Wastewater	—	—	—
Natural Gas	—	—	—
Telephone	—	—	—
Flood Control	—	—	—

installation necessary for the systems to function (see Table 2).(7) Some of the factors that affect the loss of

- **Red** - Little or no capability, requires assistance.
- **Amber** - Some (50-75 percent) capability, requires some assistance.
- **Green** - Near pre-event capability, no assistance required.

function or usability of a facility include: direct damage (structural and nonstructural), equipment damage (facility contents), loss of personnel, damage to service lifelines at the facility, damage to remote lifelines serving the facility, and interruption of raw materials, supplies, replacement parts, and services.(9) The time necessary to restore any given facility is dependent upon the degree of damage, importance of the facility in post-event recovery (priority for restoration), availability of manpower and resources, and the availability of supplies, replacement parts, and services.(10)

Utility Services as Tools

Understanding the central role public utilities play in response, recovery, and reconstruction is important because energy, potable water, wastewater, and telecommunications services underlie all of these efforts. Electric power restoration may be the first priority, since all of the other utilities depend upon it. Most utility companies serving major metropolitan areas maintain sophisticated service control centers that monitor the status of their distribution systems. These centers can tell immediately where services have been disrupted, how many structures have been affected (and thus estimate the population that is affected), and estimate restoration time.(11) Table 3 shows an example of a power utility's general restoration priorities.

Where the People Are

There are two basic observations that are important here: [1] there will be fewer casualties (deaths and injuries) if the disaster occurs during a time when most people are at home in safer, wood-frame structures; (13) and [2] family units will try to re-group if they receive warning about an impending disaster, or will attempt to

soon after the event occurs.(14) This basic need will place demands on the communications and transportation systems, and on public officials for information about what has happened and where and who may have been affected and where they might be. (The American Red Cross operates a "Disaster Welfare Inquiry" service which attempts to capture of the welfare of those in the affected area, and match this information to inquiries they receive.)(15) Table 4 is the author's suggestion of where the population is by social function, by day of the week, and time of day. It is based on Table 5, which illustrates occupant density for various facilities, or social functions.

General Phases of Activity

Building on Quarantelli's "Agent-Generated Demands," Table 6 illustrates the types of activities that will need to be accomplished.

Data Bases

A basic disaster effects profile could be developed using the Metropolitan Statistical Area (core city and its suburbs). It would be most effectively built using a Geographic Information System (GIS) or similar mapping system that can display topographic information, structures, addresses, transportation routes, and the boundaries of the census districts. Census data is available on other databases (TIGER files). Table 7 includes examples of the data that is available on municipal GIS systems.

Building a Decision Process

Participants in the local emergency management planning process could develop a list of what they consider to be critical facilities and locate these on the mapping database. Each facility could be inventoried similar to Table 5 to get rough estimates of population per square foot by time of day. Street and highway traffic volume data is available from the metropolitan planning agency and/or the State's Department of Transportation and could be useful in aggregate form by time of day and day of the week. Seasonal variations in population (especially cities with high tourism) and locations where this is concentrated could be added to the census tract information.

Components of the Decision Process

There are key pieces of information that can help estimate the effects of a disaster and frame decision making towards current priorities and future activities. The components of the disaster's effect are those in the center, with the essential services, critical facilities, and infrastructure concerns around the periphery. The profile of what has happened, what is happening, and what is likely to happen begins with sources of information about the primary event (wind, water, fire, ground-shaking, etc.). Taking into account the type of primary event (and likely secondary effects), the time and day it occurred, whether or not there was a warning period, its magnitude or intensity, location and scope (specifically how large an area and the types of land uses in the area, including the pre-identified critical facilities), and past and present weather conditions, public safety managers can, with the GIS maps and census data, generate a profile of their current situation. Much of this information can be obtained through just a few sources.

Priorities

There are three immediate items to assess to determine if the municipality has the capabilities to resolve without external assistance:

- Priority Search and Rescue Sites (high-occupancy structures in affected area).
- Potential Population Affected (translating to human service requirements of food, clothing, housing, disaster welfare inquiry).
- Status of Infrastructure (particularly amount of damage, critical facilities that are affected, and restoration time).

Getting a good idea of the potential extent of damage, internal capacity, and any resource requirements necessary for performing general types of activities shown in Table 6 allows local managers to anticipate any shortfalls over the short term. Communicating these needs to the State and Federal Emergency Management Agency cannot be accomplished fast enough for two reasons: specific resource requirements can be acted on faster than general ones; and any assistance will probably not arrive for 12-24

hours (life-saving resources), or several days for major human services support (significant in light of the weather conditions and season of the year). Regularly communicating to the public the situation, current priorities, realistic timeframes for restoration of essential services, the procedure to use to contact missing family members, and the locations where relief services are available can help to reduce the stress caused by the event. This dialogue also can serve to somewhat manage service utilization (advising citizens only to use water for drinking and food preparation), and can help to reduce demands on certain services (transportation or communications systems). Providing mechanisms for feedback, which then is used to correct planning and operations, further improves the public's satisfaction (e.g., a Mayor's Action Center).(19) One way of gauging local capabilities and illustrating areas of need to external governments is shown in Table 10 (this approach was used to address the delivery of health and medical services after Hurricane Andrew).

The Decision Process

The basic questions that need to be asked and answered include:

A. What (The Primary Event)?

1. Type of hazard (ground-shaking, wind, water, fire, heat/cold)
2. Its magnitude and duration
3. Any secondary hazards it caused/is likely to cause

B. When (The Timing)?

1. Whether or not there was a warning period, and its length
2. The time it occurred
3. The day on which it occurred
4. The weather conditions, past, present, and expected
5. The season of the year

C. Where (Its Location and Scope)?

1. Types of land uses (residential, commercial, industrial)
2. Types of critical facilities in the area

D. Answering what (A) and when (B) should give you an idea of, respectively: the nature of the problem and a general idea about its likely effects on the infrastructure; and, where you can expect the population to be concentrated.

E. Answering where (C) involves defining the boundaries through checks of utility outages.

F. Estimating the potential population affected involves:

- Preparing the GIS map and identifying:
 - Critical facilities and high occupancy structures
 - Census tracts
- Compiling the populations of the census tracts affected (overall, the special populations and seasonal variations)

G. Defining the priority search and rescue sites involves:

- Consideration of time of day and day of the week for the critical facilities/high occupancy structures/highways in the area

H. Estimating the internal capacity to manage the event involves:

- Consideration of what has happened (magnitude, location and scope, and level of damage to essential services and critical facilities)
- Consideration of what is likely to happen (duration, weather conditions, season of the year, general activities that may need to be accomplished (see Table 6))

I. Estimating needs and projecting resource requirements involves:

- Consideration of (H) and organizing needs by function:
 - Transportation
 - Communications
 - Public works and engineering
 - Firefighting
 - Mass care
 - Health and medical services
 - Rescue

- Hazardous materials
- Food
- Energy (21)

Summary

Major metropolitan areas can do a better job of rapidly estimating the effects of a disaster. Historical reviews of the Federal Emergency Management Agency have criticized its ability to support state and local governments after a catastrophic disaster.(22) It is the author's opinion that much of the delays seen in human service delivery are due in large part to the local jurisdiction's inability to estimate damage, project resource requirements over the short-term, and request the personnel, supplies and equipment needed to address the anticipated shortfalls. Applying locally available tools such as Geographic Information Systems,(23) census data, key sources of information, and community-based planning efforts to build a decision process for quickly estimating damages and the level and types of assistance that may become necessary can help management better anticipate demands for services during and after a disaster strikes.

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